Congestive Heart Failure

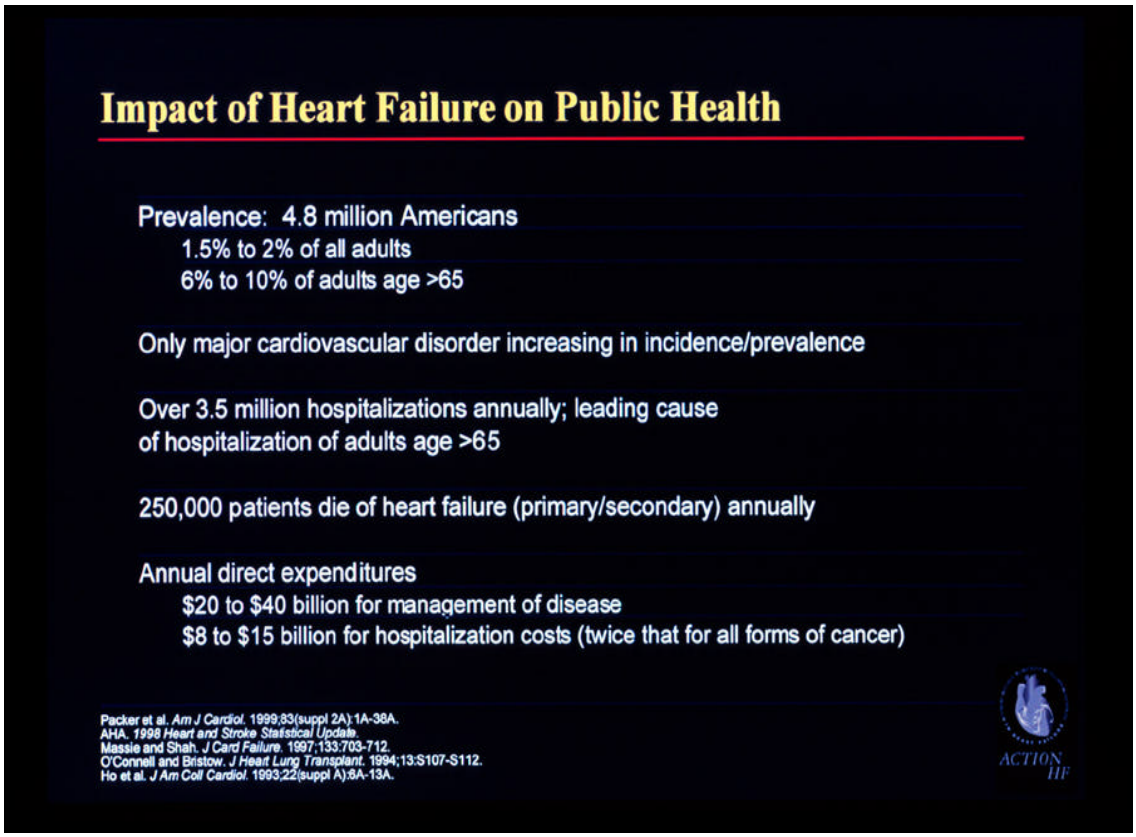
Lokesh Tejwani, MD

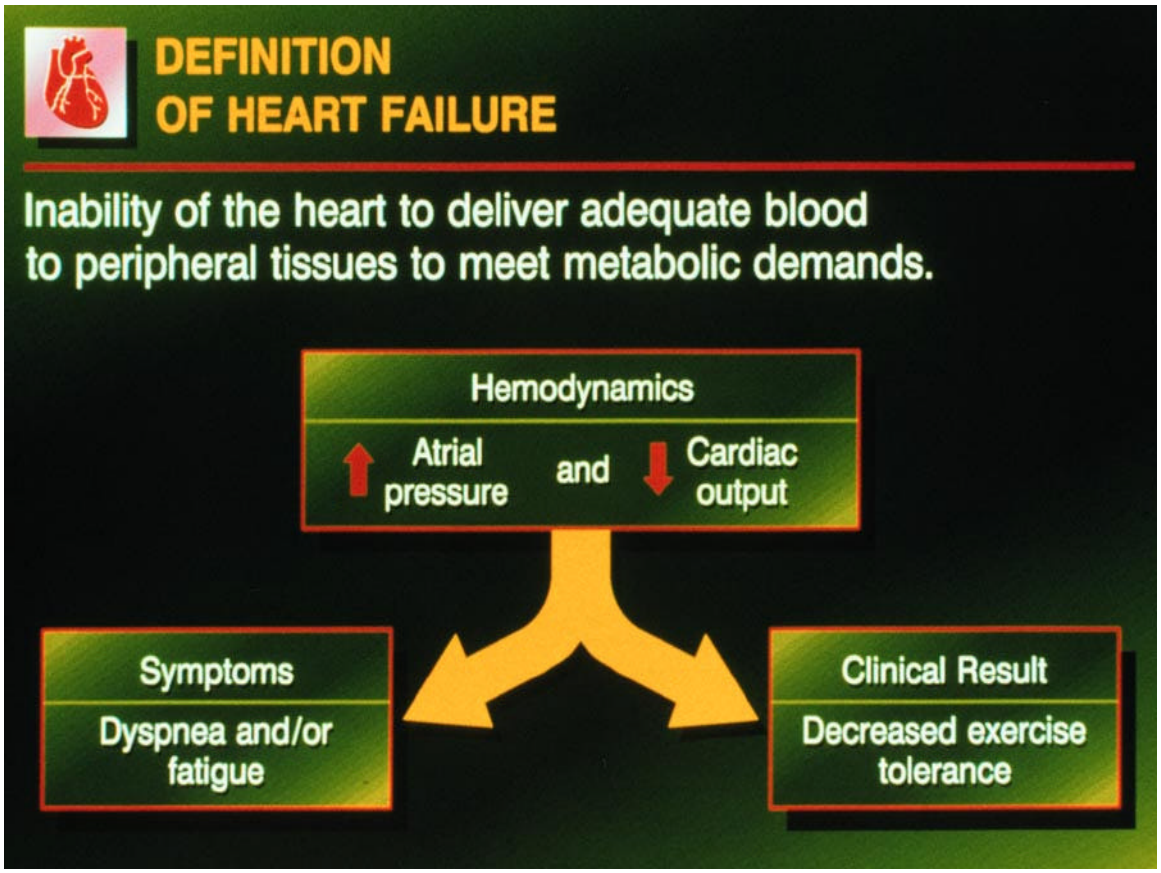
Heart Failure

"A patho-physiological state in which abnormality of cardiac function is responsible for failure of the heart to pump blood at a rate commensurate with the metabolic requirements or to do so only with elevated filling pressures"

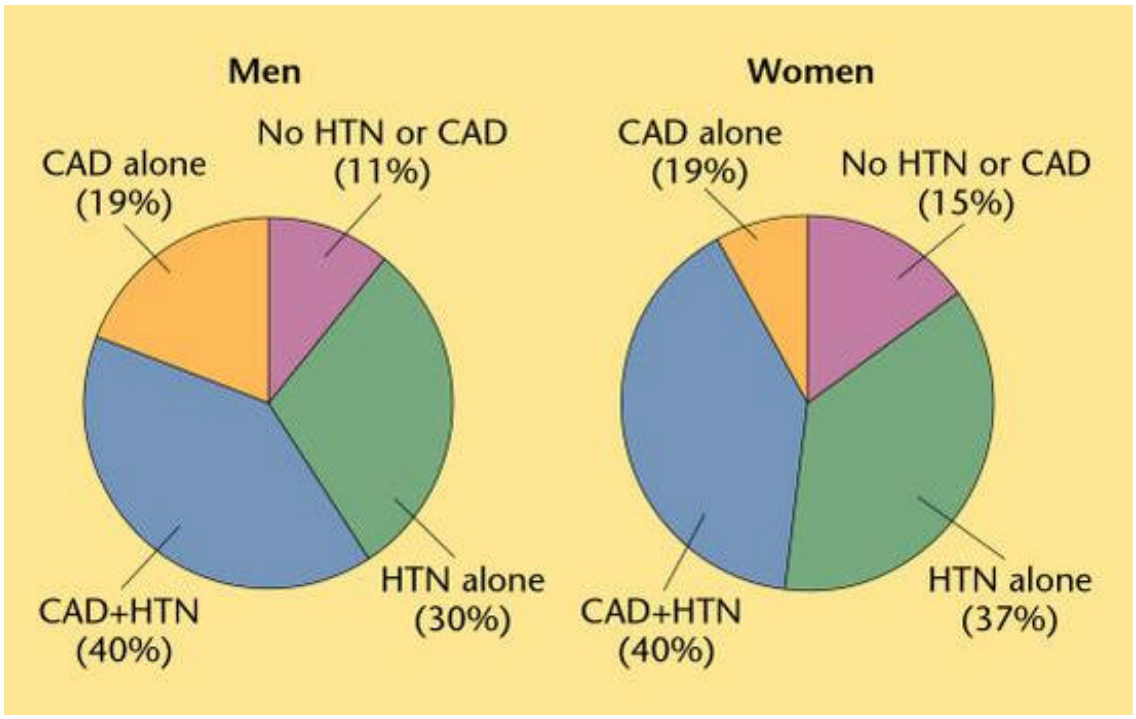
"CHF is a clinical syndrome in which heart failure is accompanied by symptoms and signs of pulmonary and/or peripheral congestion"

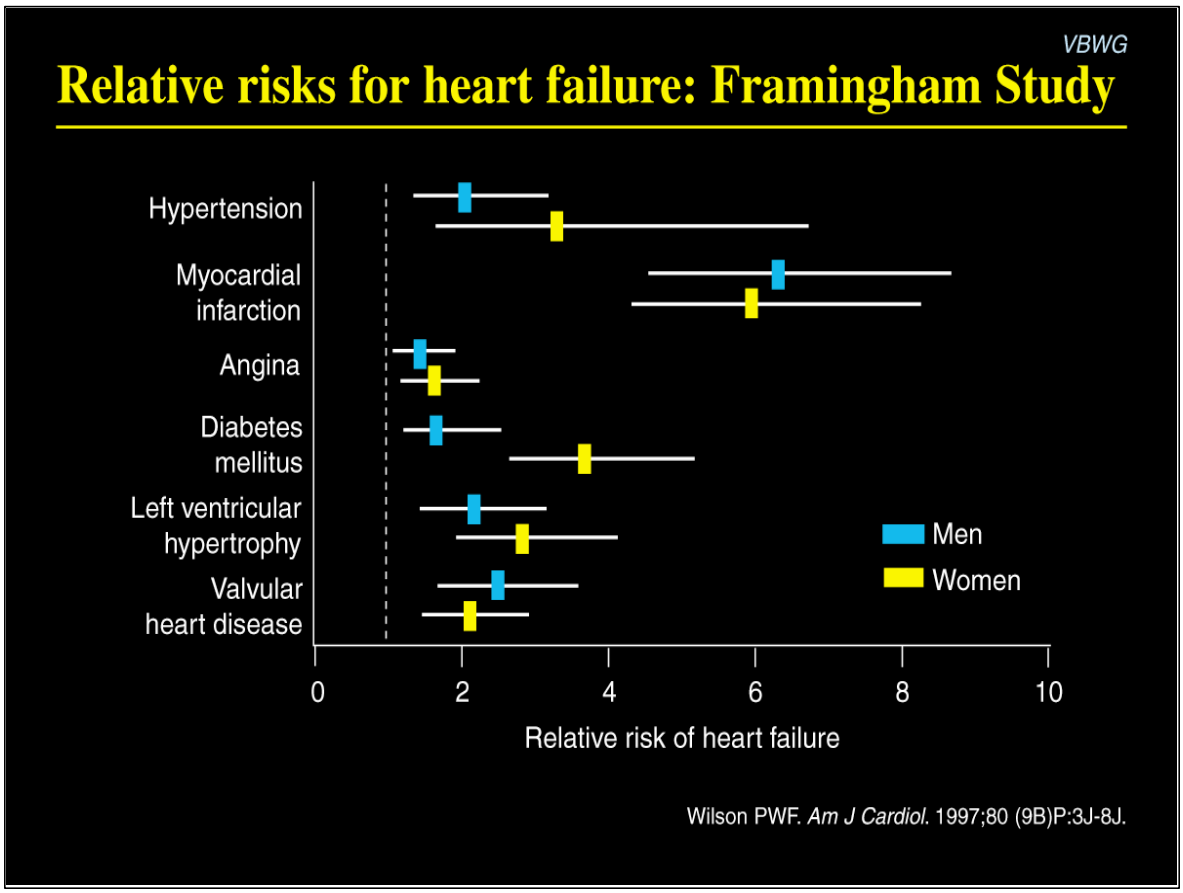
Should objective evidence of LV dysfunction be required for diagnosis of CHF?



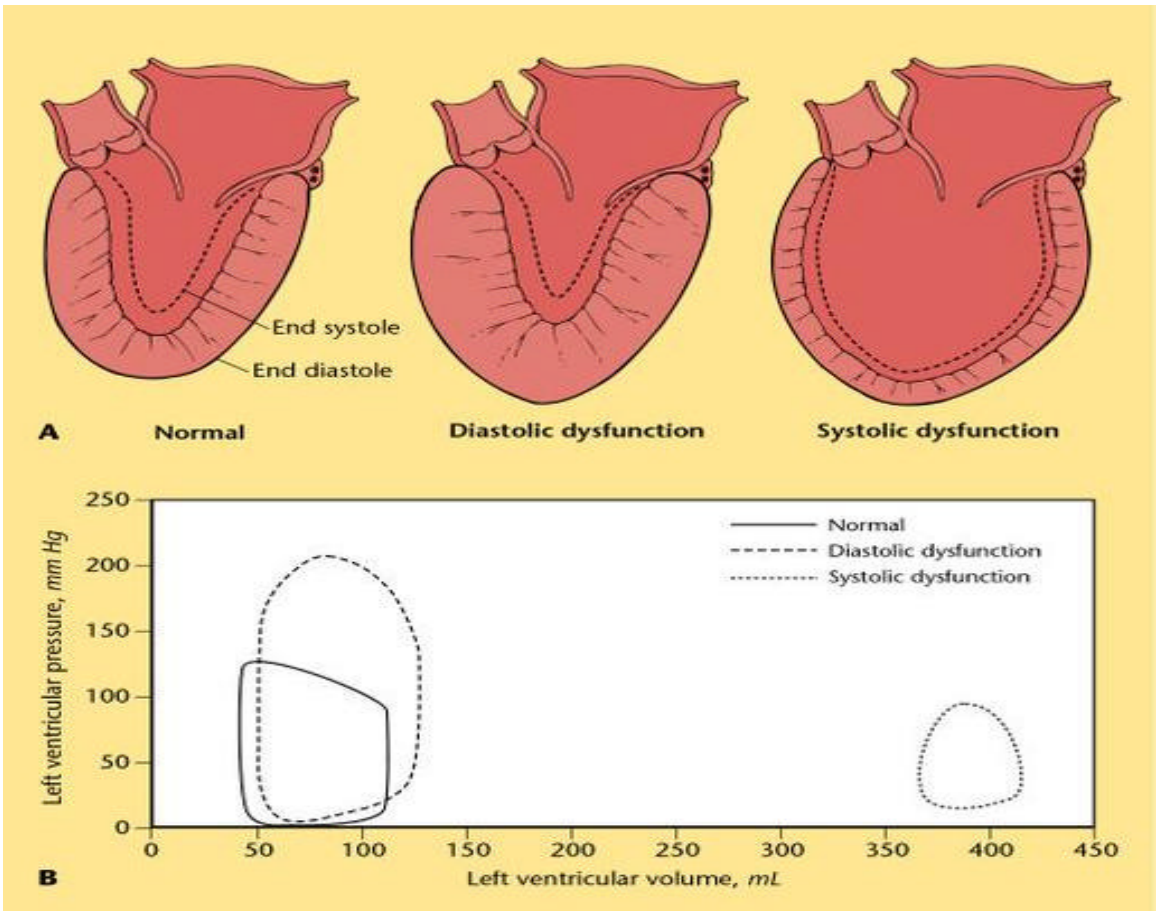


Clinical features: congestive heart failure in USA





Normal contraction: systolic and diastolic dysfunction



Pathology of Heart Failure

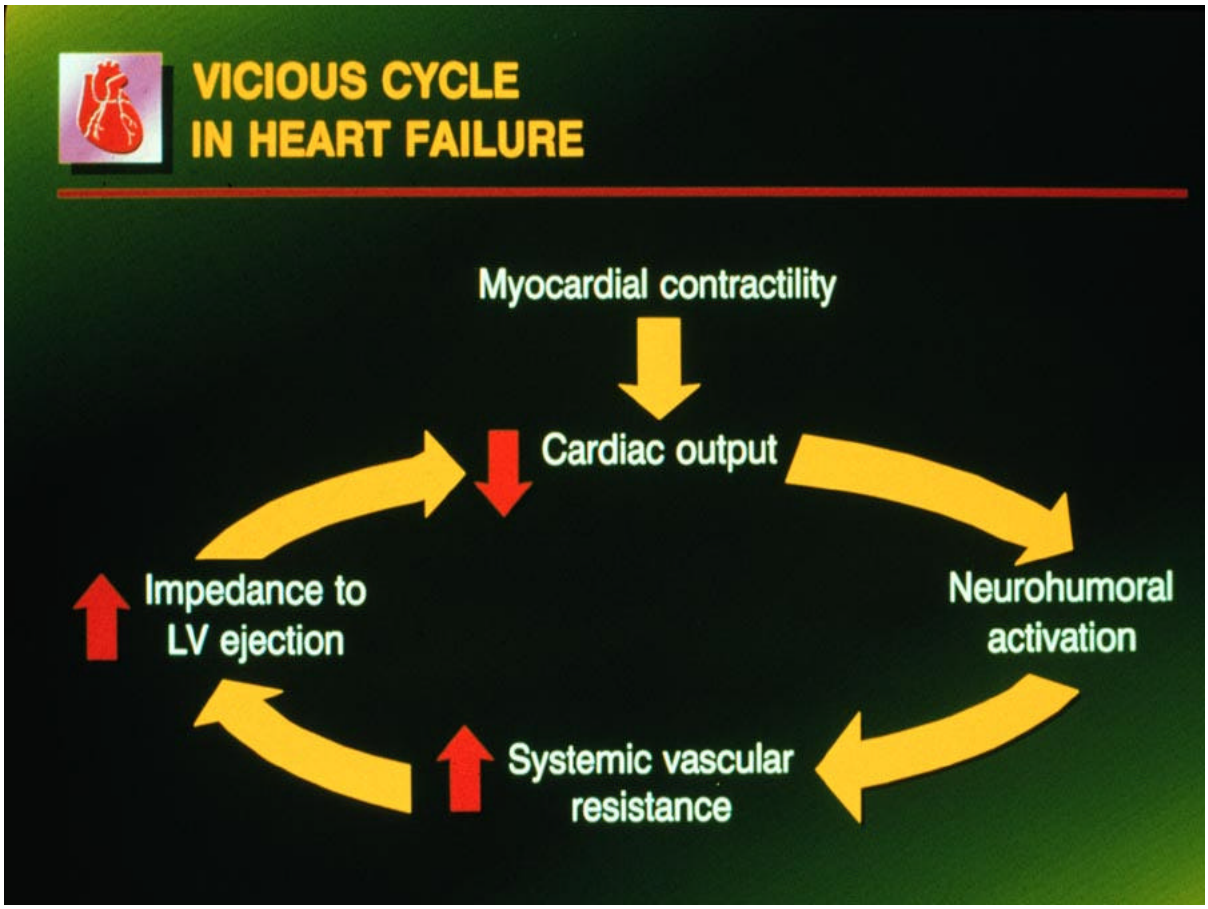
Systolic Dysfunction	
Causative Factor	Example
Loss of muscle	**Myocardial infarction**
Pressure overload	**Hypertension**
Volume overload	**Valvular regurgitation**
Decreased contractility	**Dilated cardiomyopathy**

Peripheral changes in Heart Failure

- Increased systemic vascular resistance
- Venoconstriction
- Decreased baroreceptor responsiveness
- Decreased glomerular filtration rate
- Increased arterial venous O_2 difference
- Peripheral edema

Compensatory Mechanisms that can overshoot

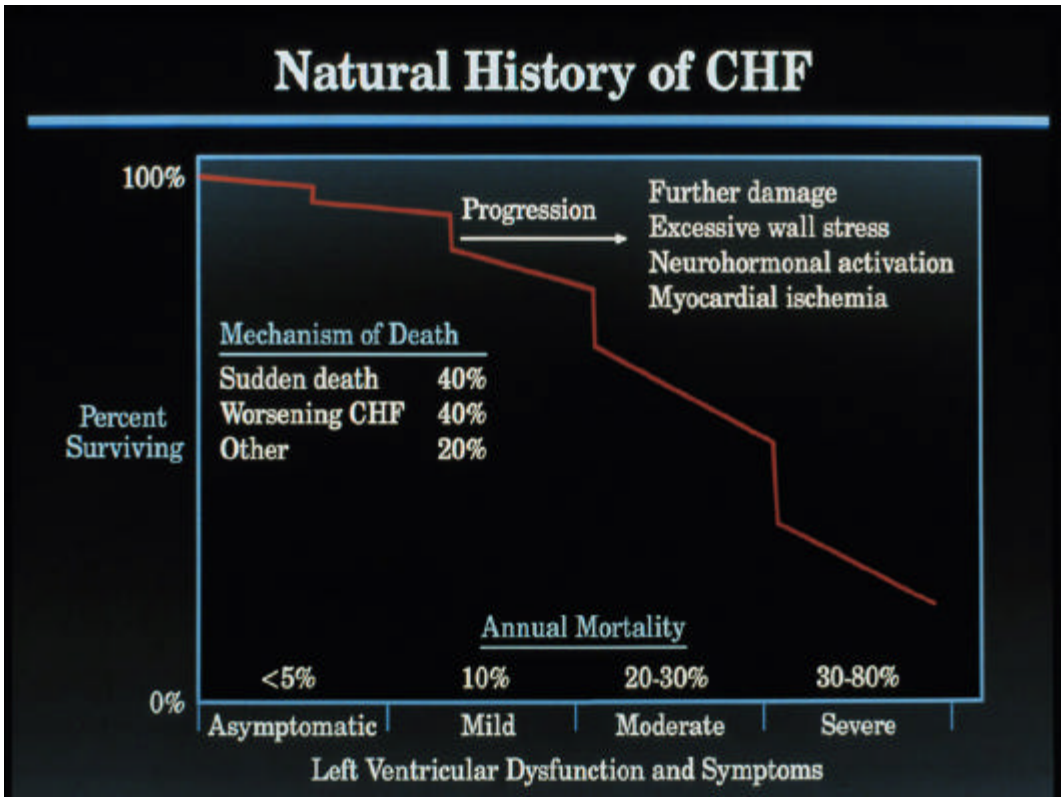
- Increased systemic vascular resitance
- Excess tachycardia
- Excess fluid retention
- Excess catecholamine secretion
- Excess rennin-angiotensin

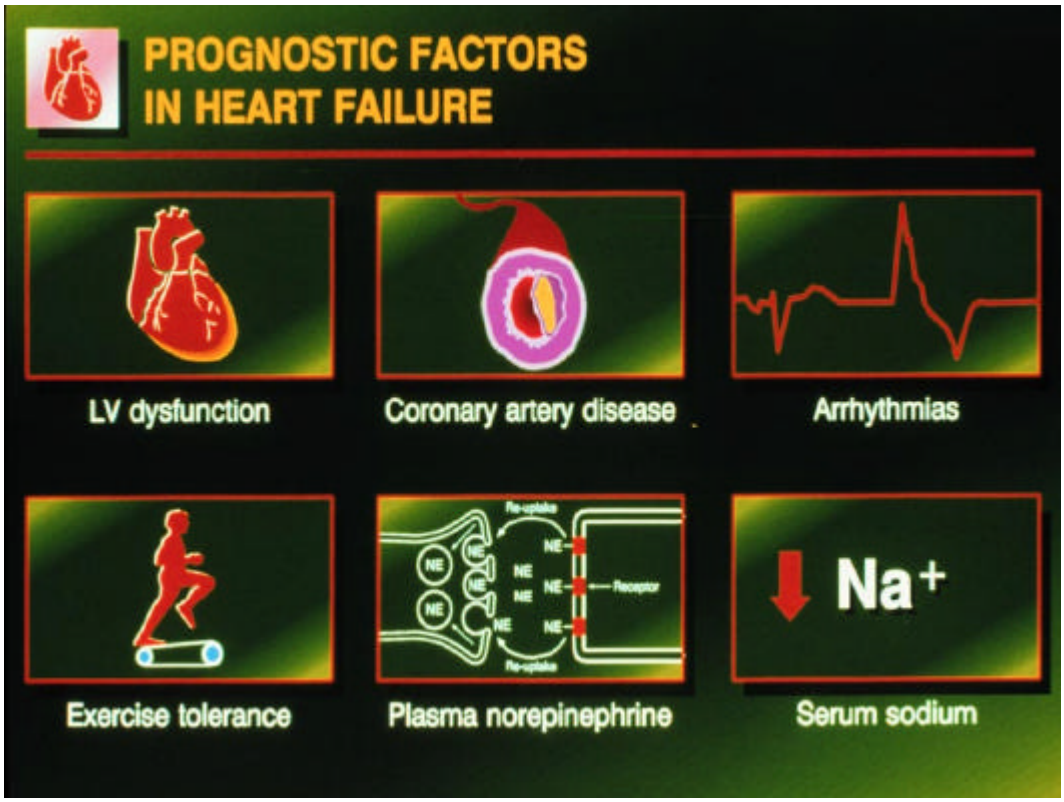


Prognosis in Heart Failure

- **In people diagnosed with heart failure, sudden death occurs at 6 to 9 times the rate of the general population**
- **5-year mortality rate is 50%**
- **Median survival following onset is 1.7 years for men and 3.2 years for women**

American Heart Association. *2001 Heart and Stroke Statistical Update.* Dallas, TX.: American Heart Association, 2000; Ho KKL et al. JACC. 1993;22:6A-13A.


Natural History of CHF
100%
Progression
Further damage
Excessive wall stress
Neurohormonal activation
Myocardial ischemia
Mechanism of Death
Sudden death 40%
Worsening CHF 40%
Other 20%
Percent Surviving
Annual Mortality
<5%
10%
20-30%
30-80%
0%
Asymptomatic
Mild
Moderate
Severe
Left Ventricular Dysfunction and Symptoms

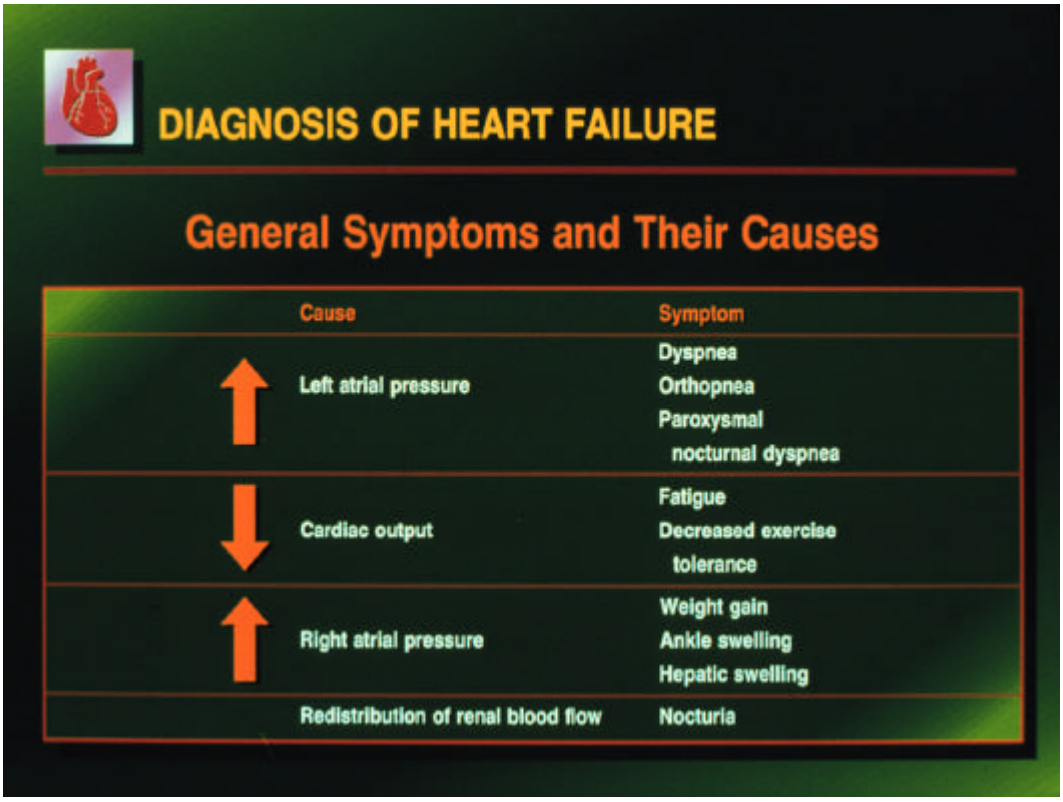

PROGNOSTIC FACTORS IN HEART FAILURE
LV dysfunction
Coronary artery disease
Arrhythmias
Exercise tolerance
Plasma norepinephrine
Serum sodium
Na+

New York Heart Association Functional Classification

I. **No limitations of physical activity, no symptoms wish ordinary activities**
II. **Mild/slight limitation, symptoms with ordinary activities**
III. **Moderate/marked limitation, symptoms with less than ordinary activities**
IV. **Severe limitation, symptoms of heart failure at rest**

Symptoms: Dyspnea or fatigue

Adapted from Criteria Committee of the New York Heart Association, 1994.



Diagnosis of Heart Failure

Signs of Physical Exam – General

- **Decrease in blood pressure**
- **Tachycardia**
- **Cardiomegaly**
- **Cool extremities**

Signs of Physical Exam –Left Heart Failure

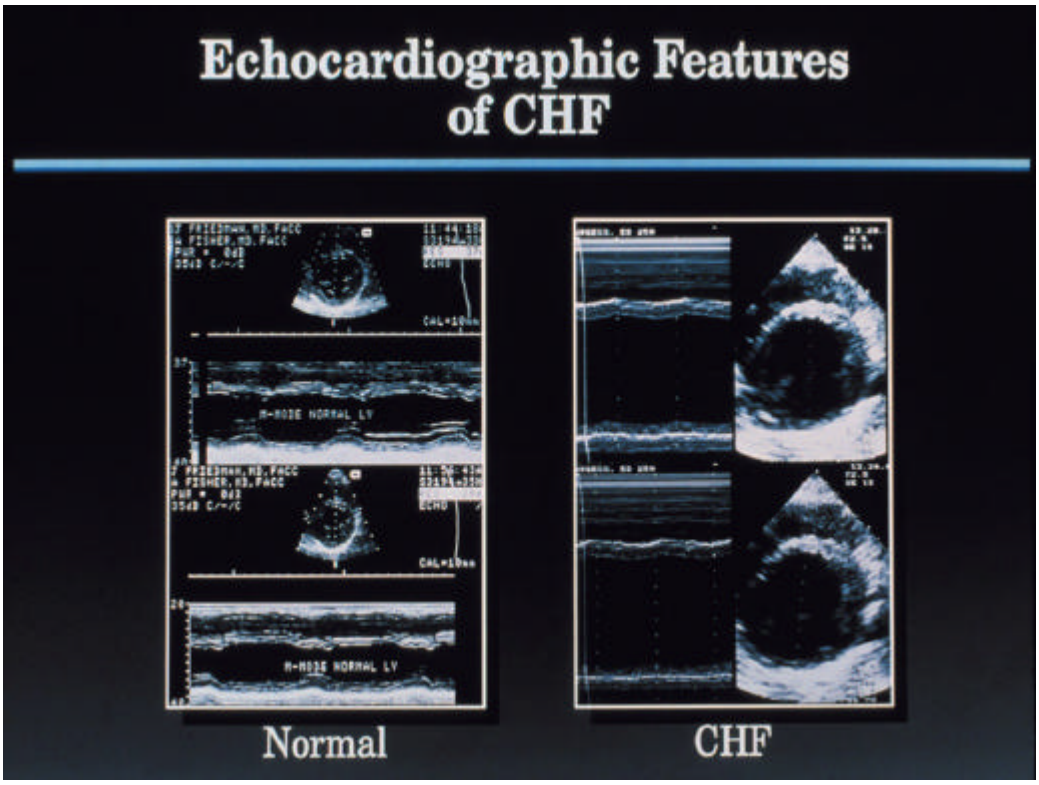
- **Rales**
- **Pleural effusion**
- **Decreased pulse pressure**
- **Pulsus alternans**
- **Abnormal apical impulse**
- **Decreased heart sounds**
- **Apical S3**
- **Mitral regurgitation**

Signs of Physical Exam – Right Heart Failure

- **Elevated jugular venous pressure**
- **Hepatojugular reflux**
- **Hepatomegaly**
- **Peripheral edema**
- **Pleural effusion**
- **Ascites**
- **Right-sided S3**
- **Tricuspid regurgitation**

Initial Testing: Rule Out Alternative Diagnoses

- **CBC (anemia, systemic illness)**
- **Chemistries (renal or hepatic dysfunction, diabetes)**
- **Urinalysis (renal disease, nephritic syndrome)**
- **Thyroid function tests (especially in AF, elderly)**
- **Arterial O_2 saturation**
- **ECG**
- **Chest X ray**
- **Measurement of LV function (usually echocardiogram)**



BNP

- **BNP is a 32 amino acid peptide.**
- **It is released in response to strech and increased volume in the ventricles.**
- **Rapid, point of care assay for BNP now available.**
- **It is helpful in Diagnosis, assessment of severity and prediction of prognosis of CHF patients.**

Physiologic Effects of the RAAS and NPS

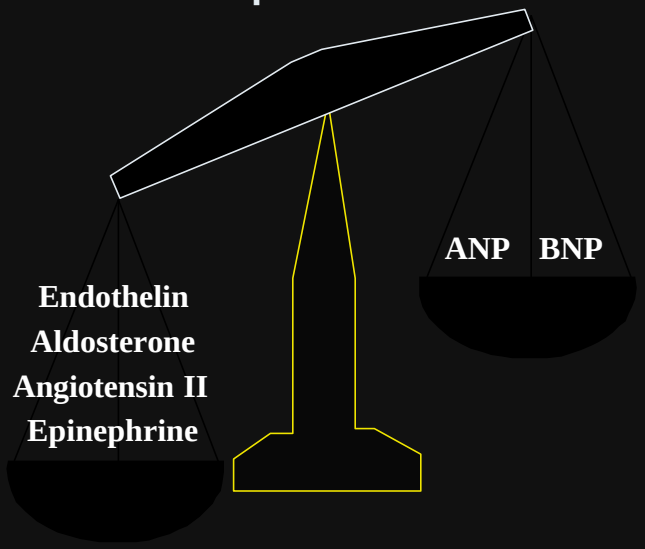
RAAS (Renin-Angiotensin Aldosterone System)

Activation of AT1 receptors by angiotensin II	**Vasoconstriction** **Sodium retention** **Increased aldosterone release** **Increased cellular growth** **Increased sympathetic nervous activity**

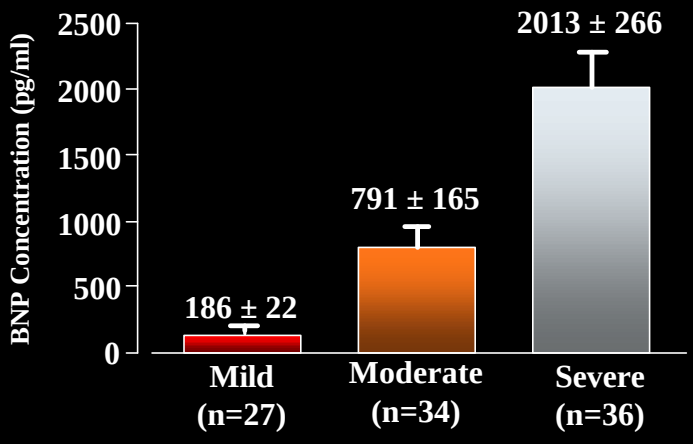
NPS (Natriuretic Peptide System)

ANP, BNP	**Sodium excretion** **Vasodilation** **Decreased aldosterone levels** **Inhibition of RAAS** **Inhibition of sympathetic nervous activity**

The Natriuretic Peptide System is Overwhelmed in Acute Decompensated Heart Failure

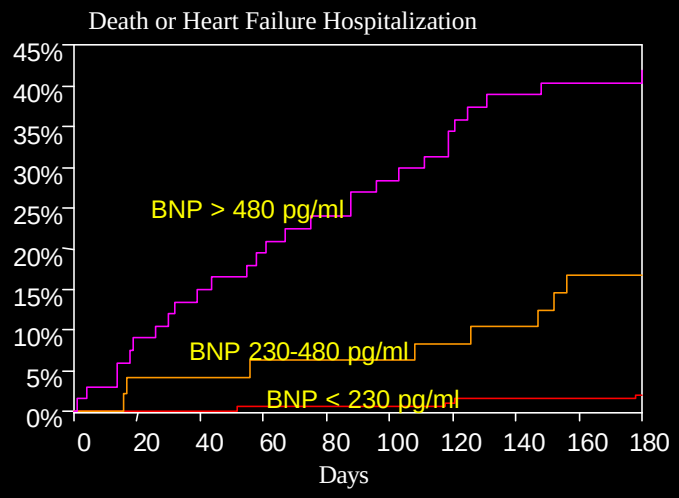


BNP Concentration for the Degree of CHF Severity



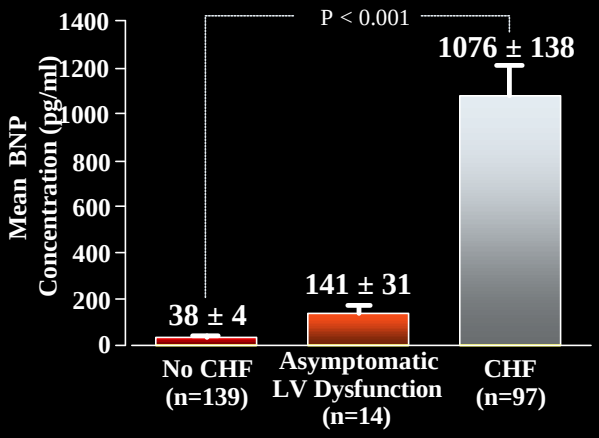
Maisel A. et al. *J Am Coll Cardiol* 2001;37(2):379-85

BNP Concentration for the Prediction of Clinical Events

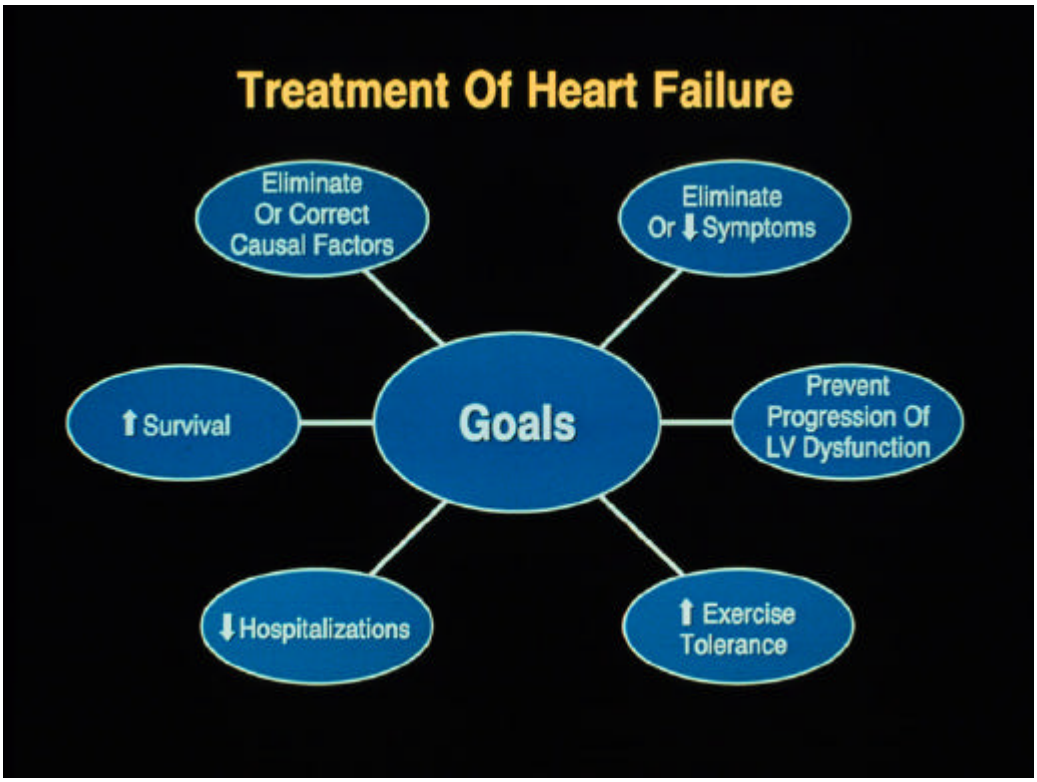


Maisel A, et al. Annals of Emergency Medicine 2001

BNP Levels of Patients Diagnosed Without CHF, With Baseline Left Ventricular Dysfunction, and With CHF



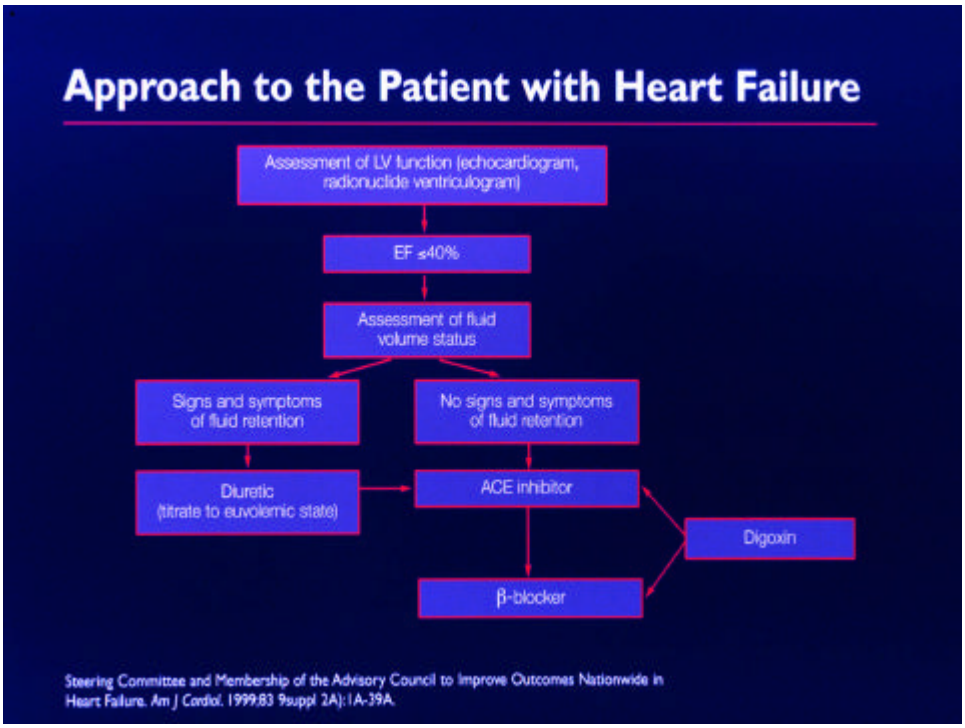
Maisel A. et al. *J Am Coll Cardiol* 2001;37(2):379-85

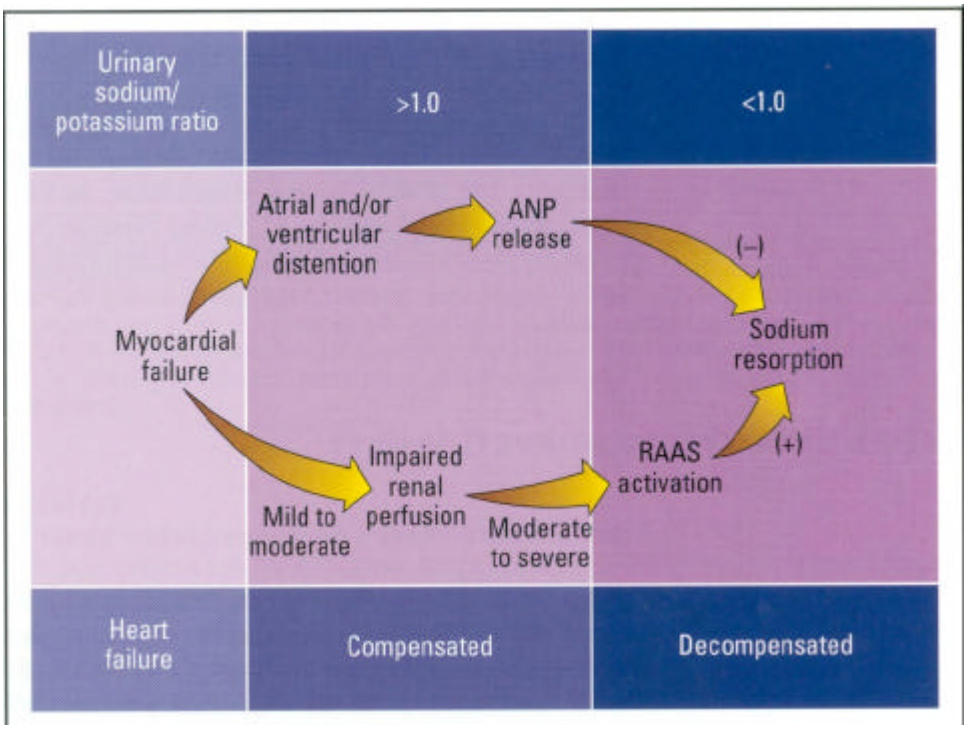


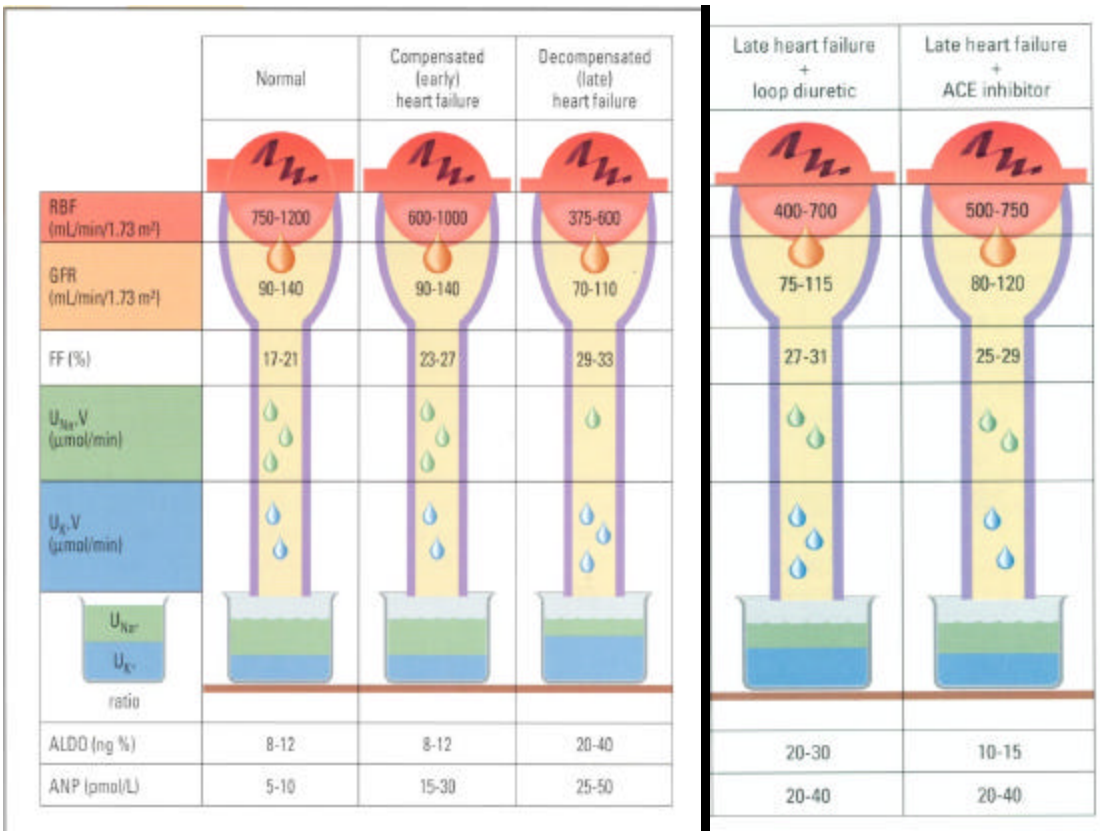
General Measures for the Management of Heart Failure

Decrease risk of new cardiac injury	**Smoking cessation; weight reduction in obese patients; control ? BP, lipids, diabetes; Discontinue alcohol use**
Maintain fluid balance	**Moderate salt restriction (= 3 grams daily); Daily weight measurement**
Improve physical conditioning	**Moderate exercise to prevent physical deconditioning**
Avoid	**Antiarrhythmic agents to suppress asymptomatic ventricular arrhythmias, Most calcium antagonists, NSAIDs**

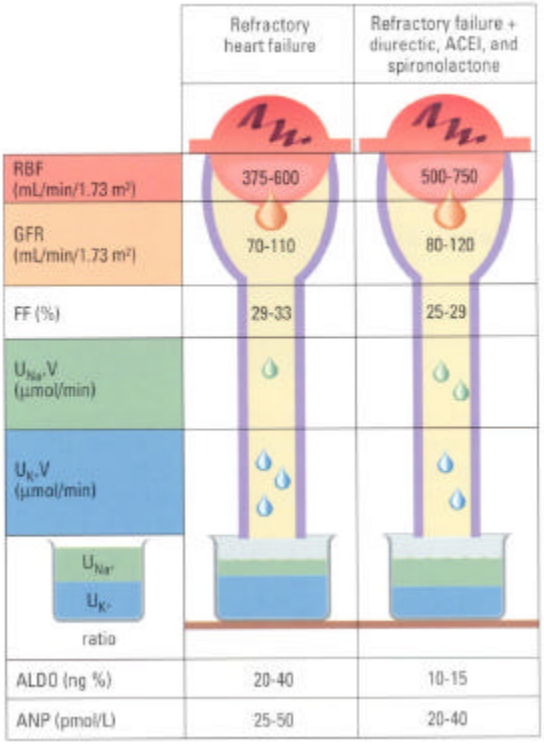
Steering committee and Membership of the Advisory Council to Improve Outcomes Nationwide in heart Failure. Am j Cardio. 1999: 83 (Suppl 2A):1A-39A.


Approach to the Patient with Heart Failure
Assessment of LV function (echocardiogram, radionuclide ventriculogram)
EF ≤40%
Assessment of fluid volume status
Signs and symptoms of fluid retention
No signs and symptoms of fluid retention
Diuretic (titrate to euvolemic state)
ACE inhibitor
Digoxin
β-blocker
Steering Committee and Membership of the Advisory Council to Improve Outcomes Nationwide in Heart Failure. Am J Cardiol. 1999;83 9suppl 2A):1A-39A.

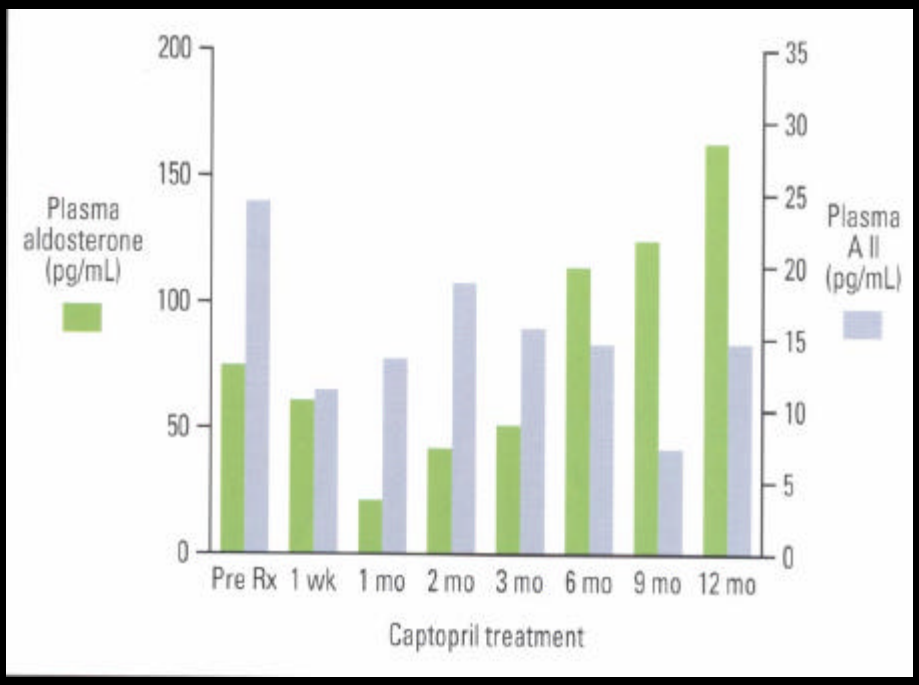

Urinary sodium/ potassium ratio
>1.0
<1.0
Atrial and/or ventricular distention
ANP release
(–)
Sodium resorption
Myocardial failure
Impaired renal perfusion
Mild to moderate
Moderate to severe
RAAS activation
(+)
Heart failure
Compensated
Decompensated



	Normal	Compensated (early) heart failure	Decompensated (late) heart failure	Late heart failure + loop diuretic	Late heart failure + ACE inhibitor
RBF (mL/min/1.73 m²)	750-1200	600-1000	375-600	400-700	500-750
GFR (mL/min/1.73 m²)	90-140	90-140	70-110	75-115	80-120
FF (%)	17-21	23-27	29-33	27-31	25-29
U_{Na^+}.V (µmol/min)					
U_{K^+}.V (µmol/min)					
U_{Na^+} / U_{K^+} ratio					
ALDO (ng %)	8-12	8-12	20-40	20-30	10-15
ANP (pmol/L)	5-10	15-30	25-50	20-40	20-40

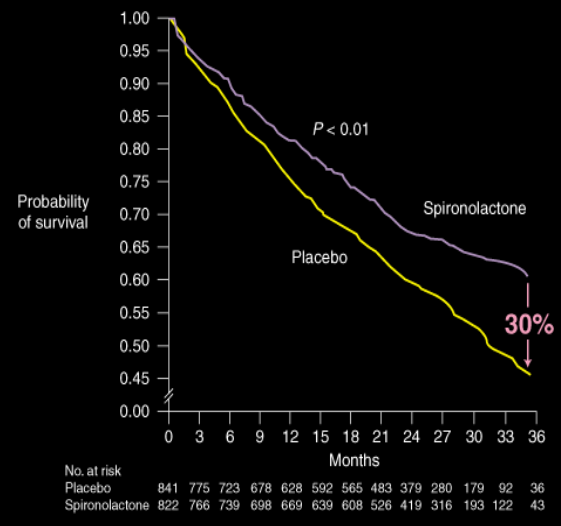


	Refractory heart failure	Refractory failure + diurectic, ACEI, and spironolactone
RBF (mL/min/1.73 m²)	375-600	500-750
GFR (mL/min/1.73 m²)	70-110	80-120
FF (%)	29-33	25-29
U_{Na^+}.V (µmol/min)		
U_{K^+}.V (µmol/min)		
U_{Na^+} / U_{K^+} ratio		
ALDO (ng %)	20-40	10-15
ANP (pmol/L)	25-50	20-40



VBWG

RALES: Aldosterone receptor blockade improves outcomes in severe heart failure

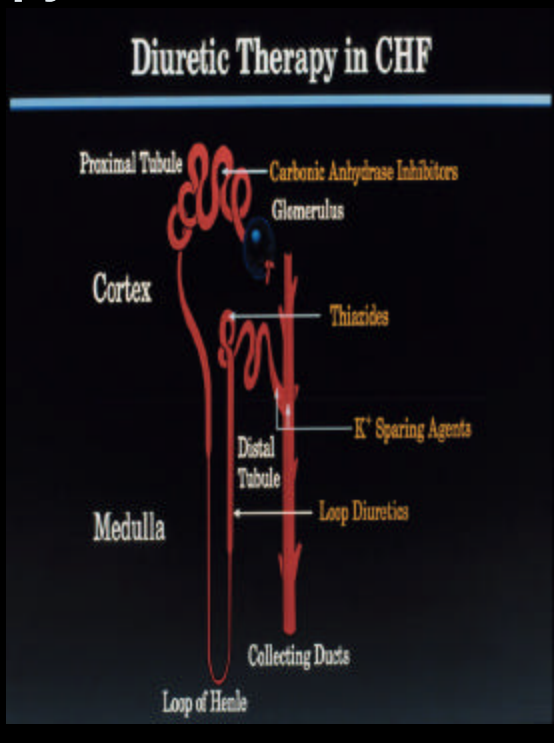


RALES = Randomized Aldactone Evaluation Study

Pitt B, et al. *N Engl J Med.* 1999;341:709-717.

Diuretic therapy in CHF

- First line therapy in symptomatic CHF
- Produce most rapid symptomatic benefit
- Need not be limited to loop diuretics
- Activate neurohormonal responses
- Induce potassium and magnesium loss



Diuretics: Recommendations

Generally prescribed for all patients with heart failure and past or present history of fluid retention

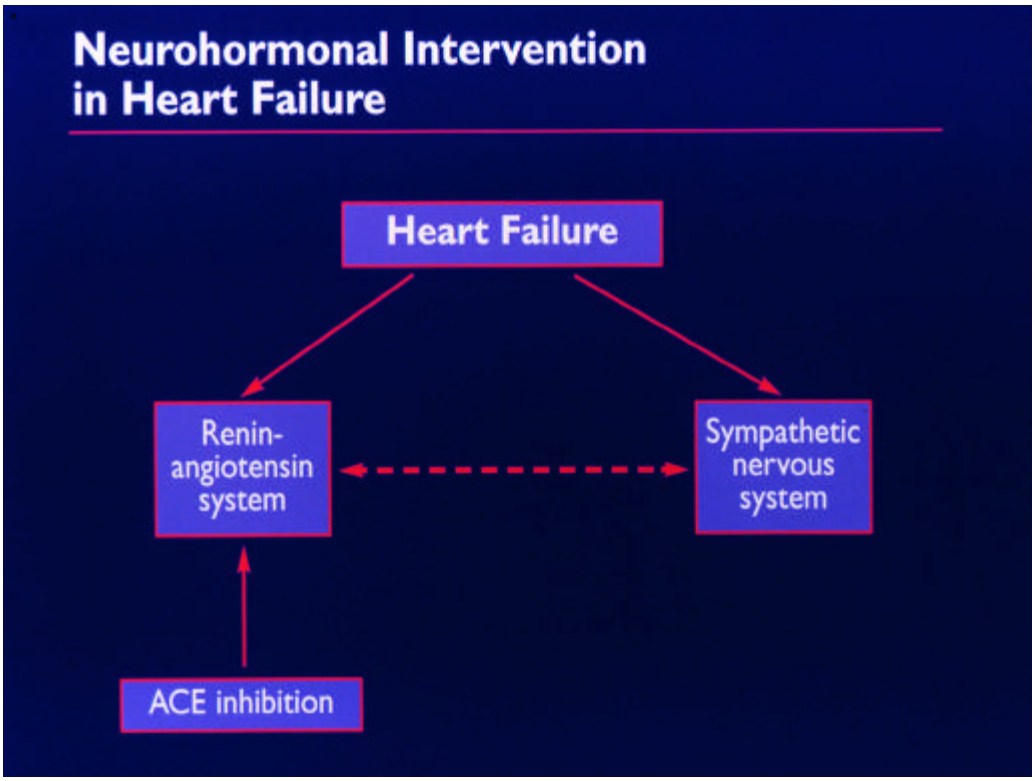
Should not be used as monotherapy even if symptoms of heart failure are controlled and if patient's clinical status is stabilized

Should generally be combined with ACE inhibitor and ß-blocker

Ultimate goal is to reduce symptoms and eliminate signs of fluid retention through continued treatment

Daily measurement of patient's weight provides guide to drug dosage and Efficacy

Packer et al. Am J Cardio 1999: 83 (Suppl 2A): 1A-38A



ACE Inhibition: Effect on Renal Function

ACE inhibition reduces angiotension II

⇩

Efferent arterial vasoconstriction reversed

⇩

GFR reduced

⇩

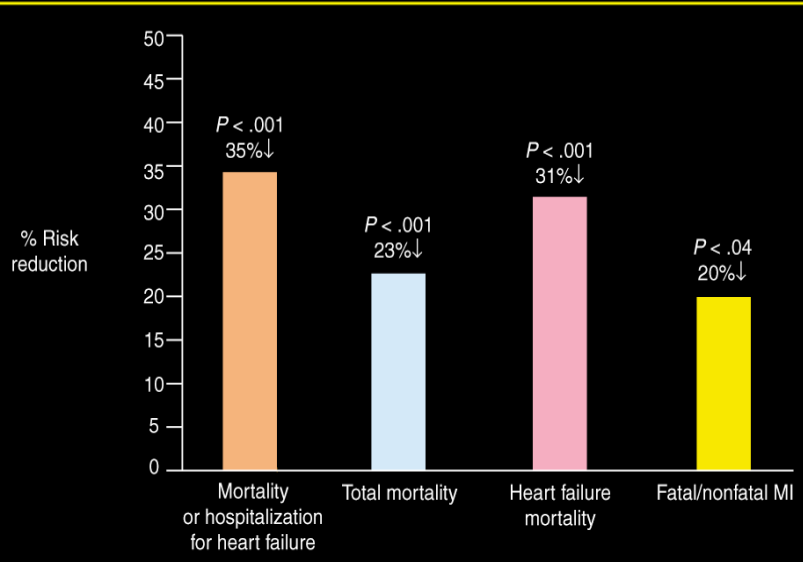
Filtration of BUN and serum creatinine reduced

⇩

BUN and serum creatininte levels increase

VBWG

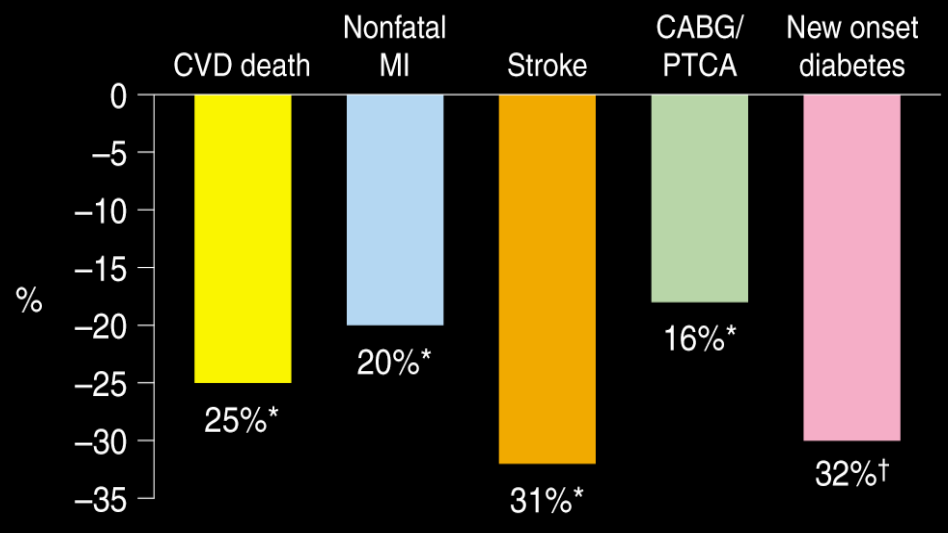
Effect of ACE inhibition on morbidity and mortality in heart failure patients – an analysis of 32 trials



Garg R, Yusuf S. *JAMA*. 1995;273:1450-1456.

VBWG

HOPE: Risk reduction with ACE inhibition



*P < .001
†P = .002

HOPE Study Investigators. *N Engl J Med*. 2000;342:145-153.

ACE Inhibitors: Recommendations

Use for all patients with heart failure caused by LV systolic dysfunction (with/without HF symptoms) unless contraindicated

Use with diuretics inpatients with present or past history of fluid retention

Use for long-term management, not for stabilizing acutely-ill patients

Initiate at very low doses, followed by gradual dose increments as tolerated

Assess renal function and serum potassium periodically

Packer et al. Am J Cardio 1999: 83 (Suppl 2A): 1A-38A

VBWG

Some contrasts between angiotensin receptor blockade and ACE inhibition

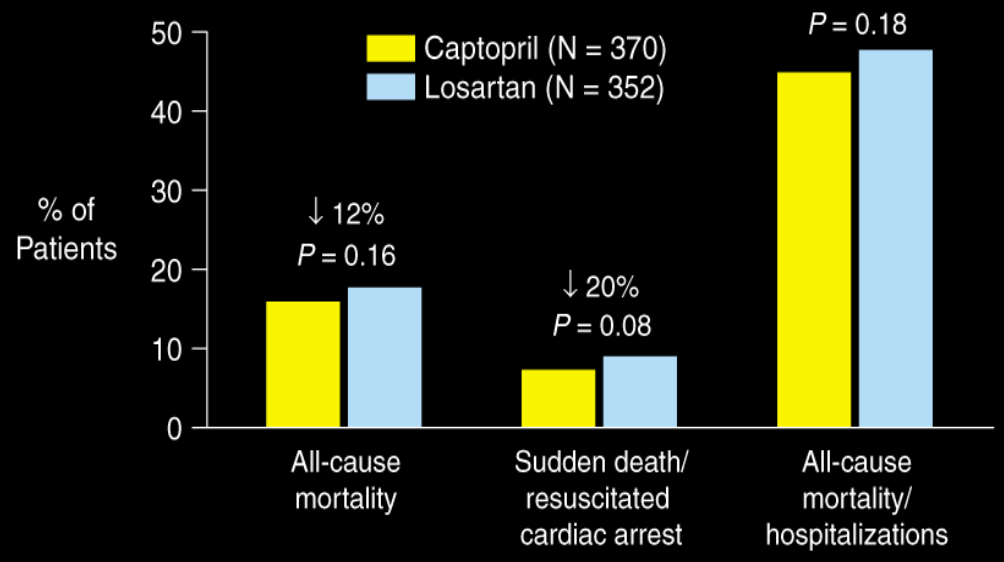
Principal mechanism of action	ARBs	ACE-I
A-II vasoconstriction	↓	↓
Plasma A-II	↑	↓
Plasma renin activity	↑	↑
Aldosterone	↓	↓
Bradykinin	—	↑
Prostaglandin E_2 and prostacyclin	—	↑
Nitric oxide release	—	↑
Uric acid levels	↓↑	—
Cough	Not observed	Class specific

Adapted from Messerli FH, et al. *Arch Intern Med.* 1996;156:1957-1963.
Chrysant SG. *Am Heart J.* 1998;135:S21-S30.
Baruch L, et al. *Circulation.* 1999;99:2658-2664.

— = no effect

VBWG

ELITE II: ARB vs ACEI in heart failure

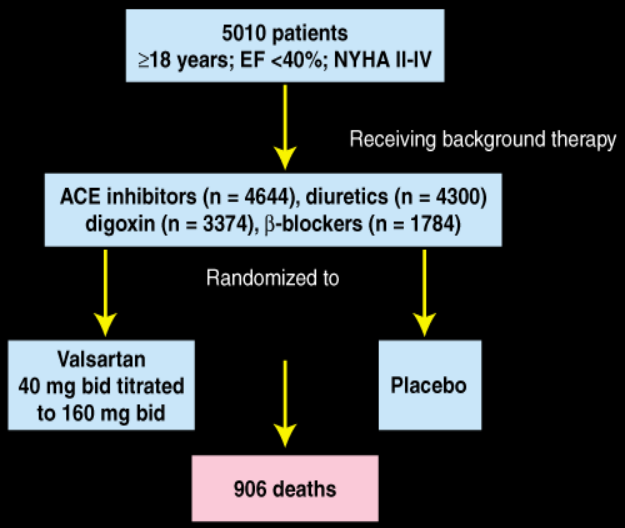


ELITE II = Evaluation of Losartan in the Elderly

Pitt B, et al. *Lancet*. 2000;355:1582-1587.

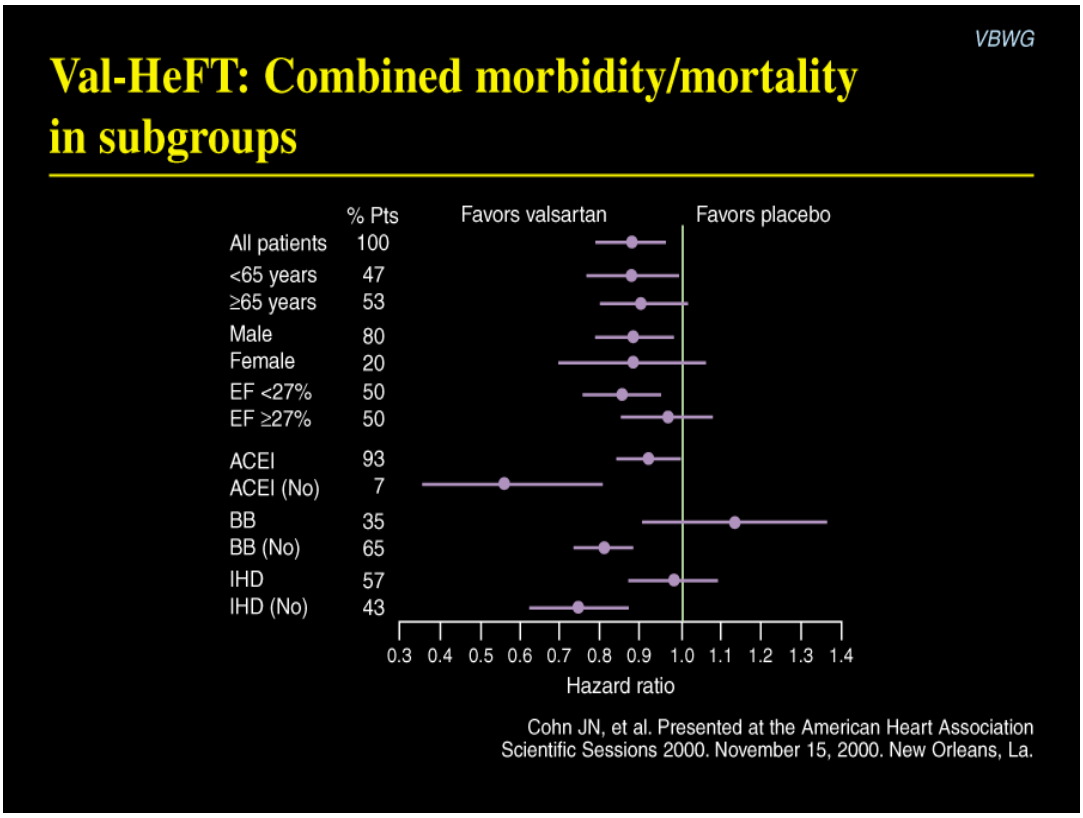
VBWG

Val-HeFT: ARB vs usual therapy in heart failure – study overview



Val-HeFT = Valsartan in Heart Failure Trial

Cohn JN, et al. Presented at the American Heart Association Scientific Sessions 2000. November 15, 2000. New Orleans, La.



ACE inhibitors vs ARBs in heart failure: Clinical summary

- **Ace inhibitors: Remain the first choice for treatment of patients with heart failure**
- **Angiotensen receptor blockers: Consider as an alternative for patients who cannot tolerate ACE inhibitors, or as adjunctive therapy with ACE inhibitors**
- **For patients taking both ACE inhibitors and ß-blockers the addition of an ARB has no benefit and may be contraindicated**

Jamli AH, et al. Arch Int Med 2001; 161:667-672. Cohn JN et al. Presented at the American Heart Assoc. Scientific Sessions 2000. November 15, 2000, New Orleans, LA

Digitalis: Use in Clinical Practice and Recommendations

Digoxin alleviates symptoms and improves clinical status, thus decreasing risk of hospitalization, but has little or no effect on survival.

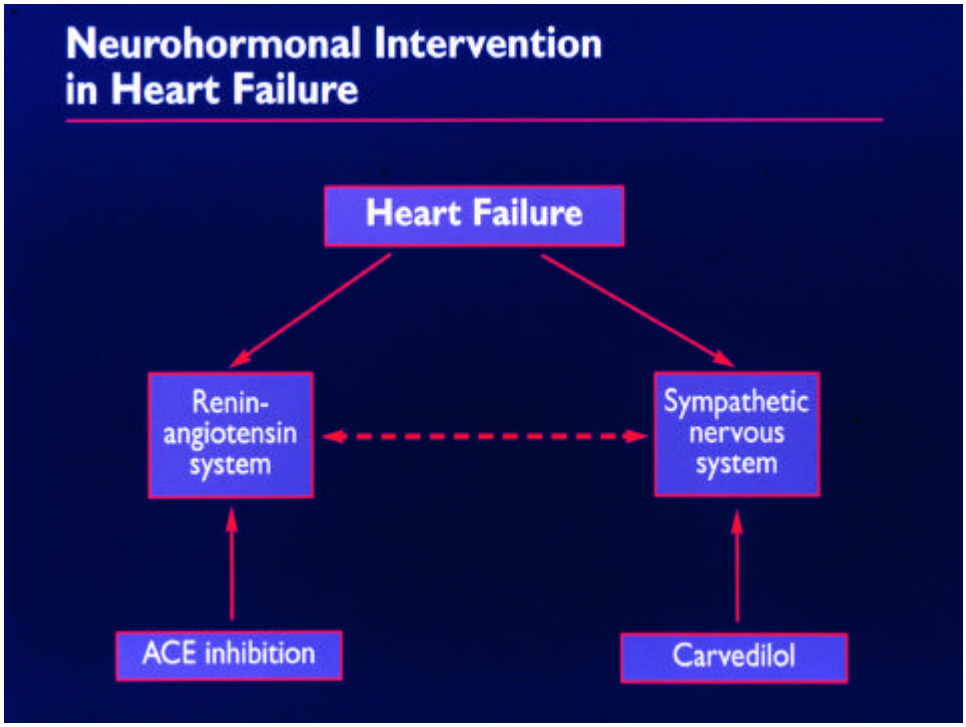
Recommendations: Use to improve clinical status of patients with heart failure due to LV systolic dysfunction.

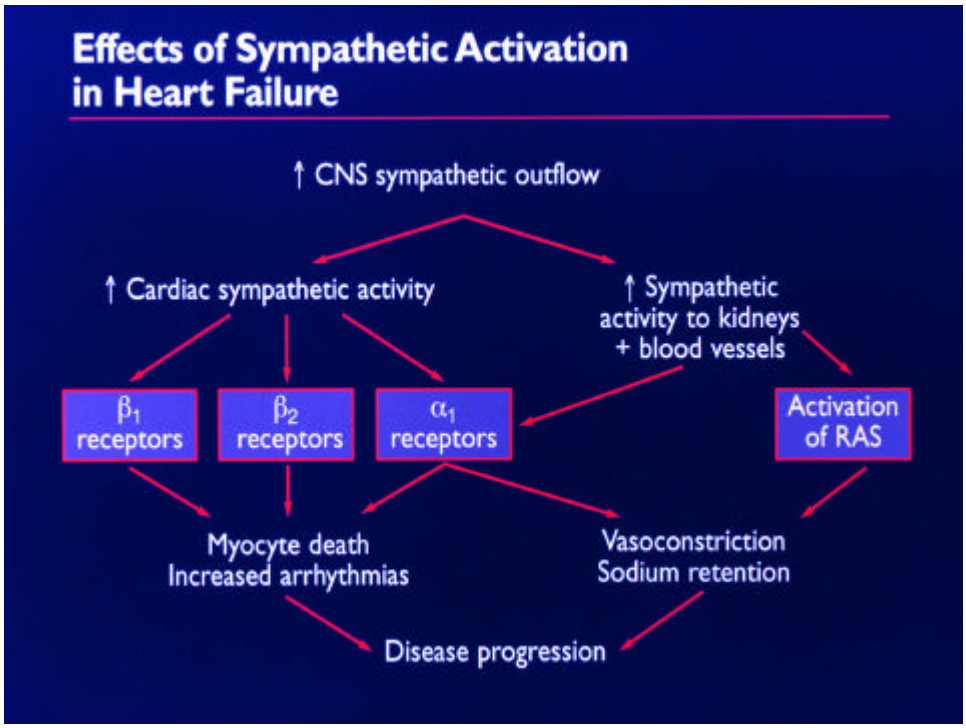
Use with diuretic, ACE inhibitor, and ß-blockers.

Packer et al. Am J Cardio 1999: 83 (Suppl 2A): 1A-38A
Digitalis Investigation Group. N Engl J Med 1997; 336:525-533

Direct Vasodilator Therapy in CHF

- **Improve LV performance by reducing afterload and preload**
- **Increase cardiac output and reduce LVFP**
- **Hydralazine + isosorbide dinitrate prolongs survival**
- **Produce only limited symptomatic improvement**
- **Activate neurohormonal response**
- **Frequently associated with tolerance and side effects**





ß-Adrenergic Receptor Blockers

ß-Blockers primarily inhibit effects of sympathetic nervous system

Deleterious effects of sympathetic nervous system are mediated through actions on $ß_1$-, $ß_2$-, and a_1-adrenergic receptors

Three types of ß-Blockers; those that:

- **Selectively inhibit ß-adrenergic receptors (eg,metoprolol and bisoprolol)**
- **Inhibits both $ß_1$- and $ß_2$-adrenergic receptors (eg, propranolol and bucindolol)**
- **Inhibit $ß_1$- and $ß_2$- and a_1-adrenergic receptors (eg, carvedilo)**

Carvedilol is the only ß-blocker approved by the FDA for management of chronic heart failure.

Packer et al. Am J Cardio 1999: 83 (Suppl 2A): 1A-38A

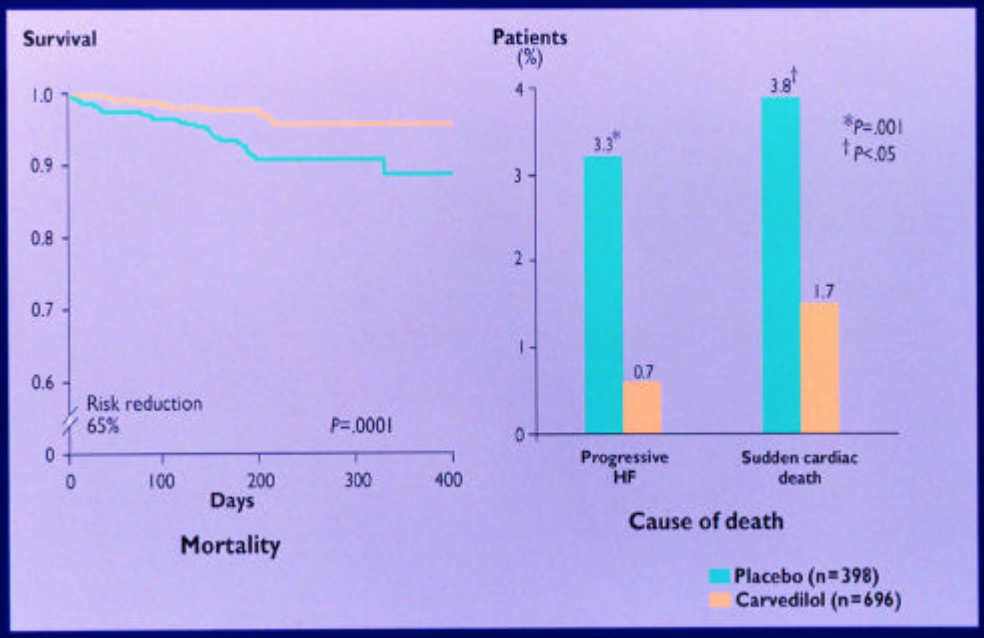
VBWG

β-blockers in heart failure: Key clinical trials

Trial	Drug	Target daily dose	Risk reduction/ total mortality
US Carvedilol (n = 1094)	Carvedilol	50-100 mg	65% (*P* < 0.001)
MERIT-HF (n = 3718)	Metoprolol	200 mg	34% (*P* = 0.0062)
CIBIS II (n = 2647)	Bisoprolol	10 mg	33% (*P* < 0.0001)

Smith AJ, et al. *Am J Health Syst Pharm.* 2001;58:140-145.

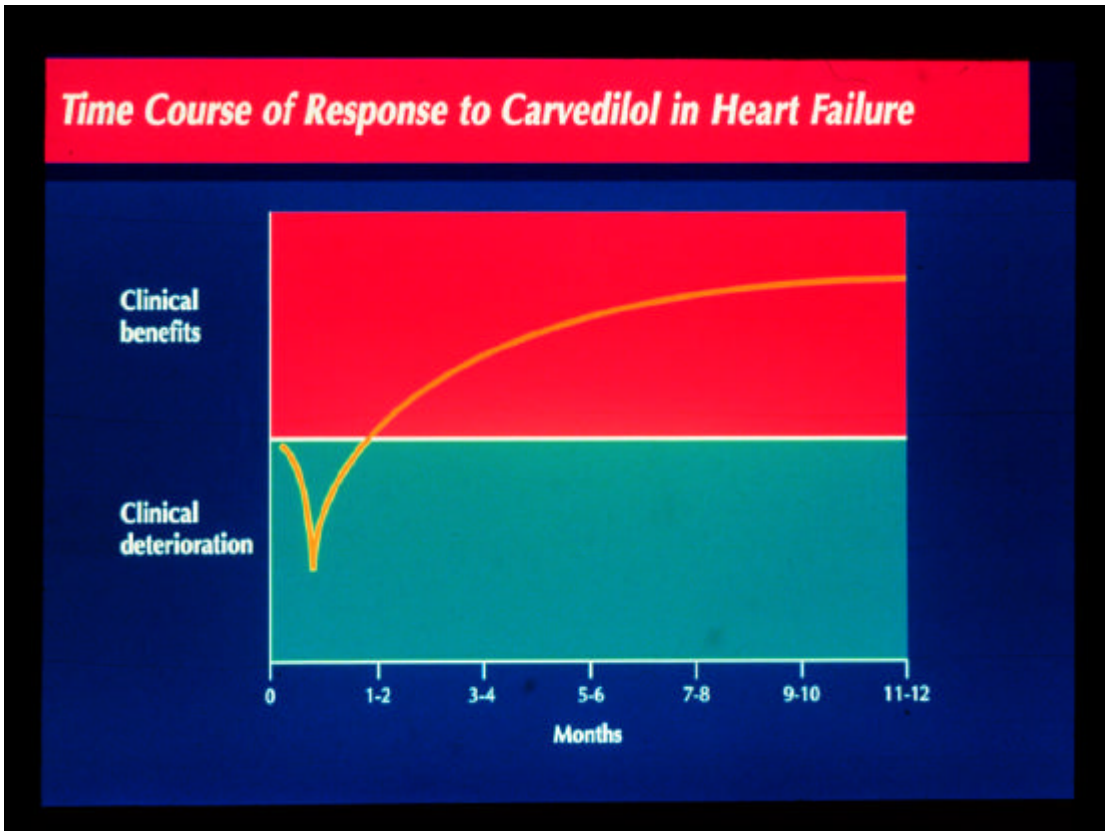
Mortality in US Carvedilol Heart Failure Program



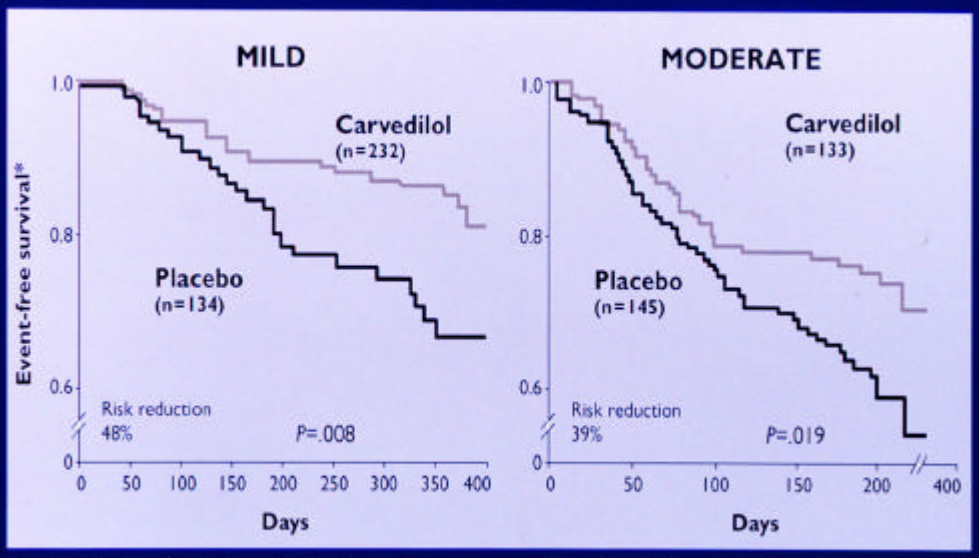
Patients receiving diuretics, ACE inhibitors, ± digoxin; mean follow-up 6.5 months.

Adapted from Packer et al, 1996.

Time Course of Response to Carvedilol in Heart Failure



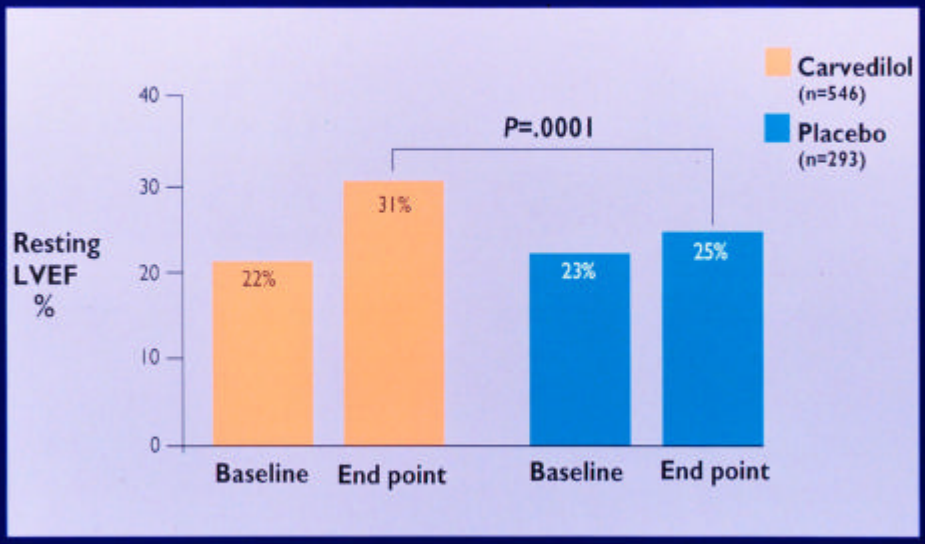
Effect of Carvedilol on Progression in Mild or Moderate Heart Failure



Patients receiving diuretics, ACE inhibitors, ± digoxin.
Colucci et al, 1996.

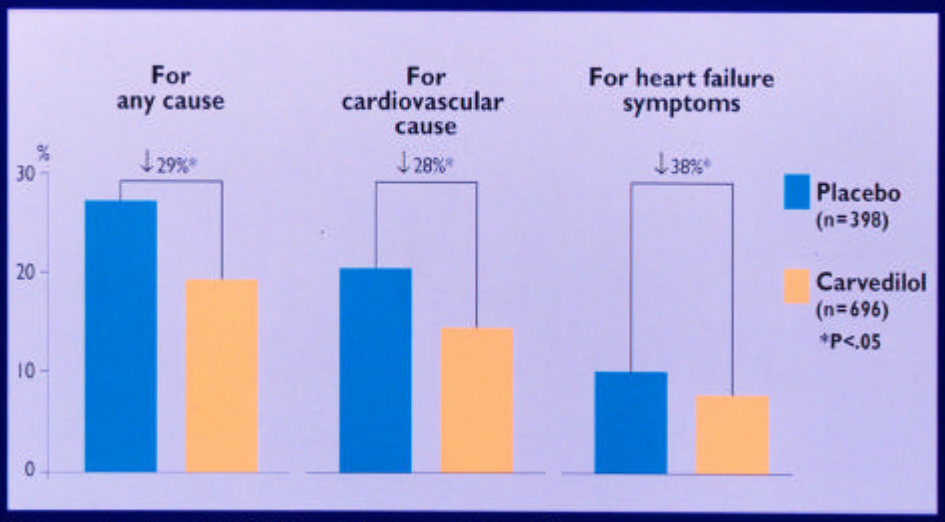
*All-cause mortality or cardiovascular hospitalization.
Packer et al, 1996.

Effect of Carvedilol on Left Ventricular Ejection Fraction

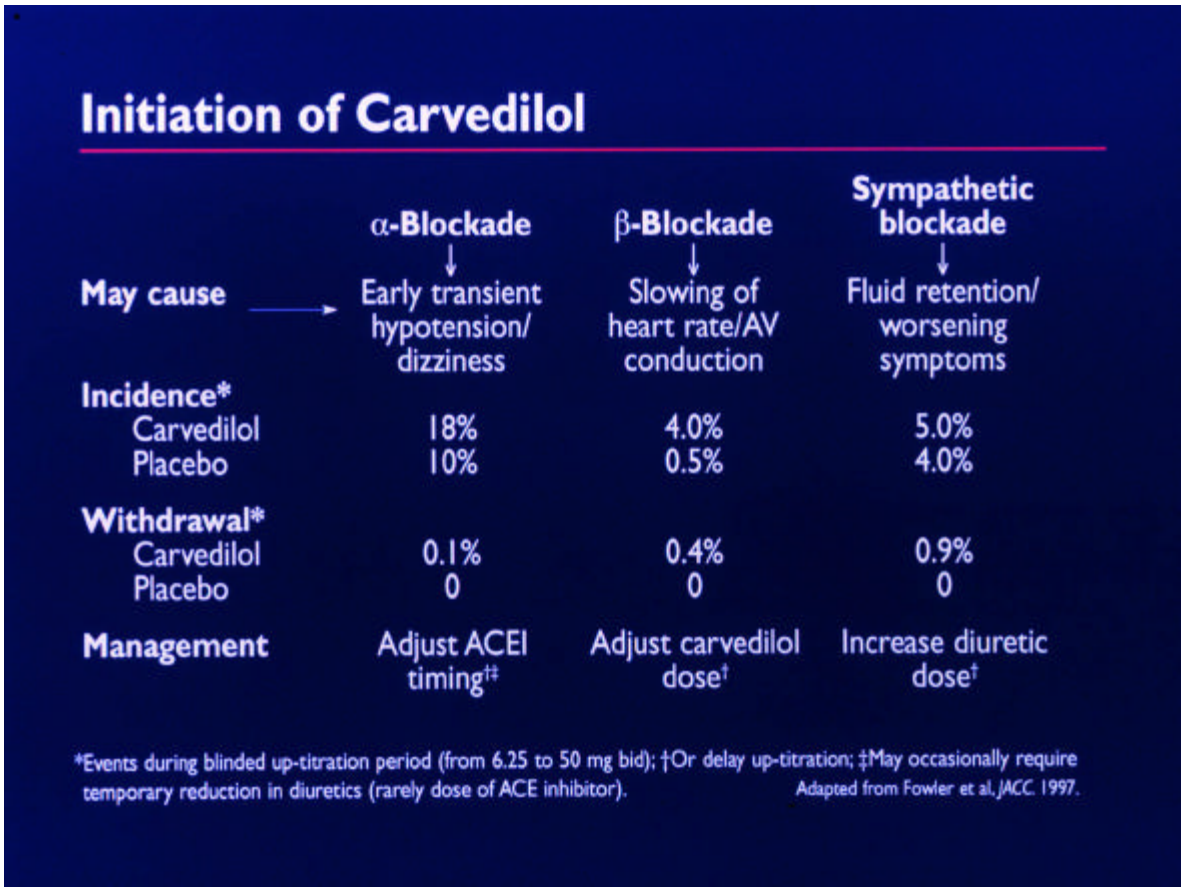


Data from 4 US double-blind placebo-controlled trials; mean follow-up 6.5 months.
Patients receiving diuretics, ACE inhibitors, ± digoxin.

Effect of Carvedilol on Hospitalizations in Heart Failure



Patients receiving diuretics, ACE inhibitors, ± digoxin; mean follow-up 6.5 months.
Adapted from Fowler et al, 1996.



ß-Blockade: Recommendations

Use for all patients with stable NYHA Class II or III heart failure due to LV systolic dysfunction unless contraindicated

Use with diuretic and ACE inhibitors; endure that patients are not fluid-overloaded

Use for long-term management, not for stabilizing acutely-ill patients

Initiate at very low doses, followed by gradual dose increments as tolerated

Monitor patients for hypotension, bradycardia, and fluid retention during uptitration period (85-90% of patients in clinical trials were maintained on long-term therapy)

Aims of heart failure management and therapeutic approaches

To achieve improvement in symptoms

- **Diuretics**
- **Digoxin**
- **ACE inhibitors**

To achieve improvement in survival

- **ACE inhibitors**
- **ß-blockers**
- **Oral nitrates pous hydralazine**
- **Spironolactone**

Davies MK, et al. BMJ 2000; 320:428-431

Common Errors in the Management of Heart Failure

- **Other conditions and reversible causes not identified or treated**
- **Heart failure not considered (COPD misdiagnosed)**
- **LV function not assessed**
- **Inadequate pharmacologic treatment**
- **Noncompliance not addressed**
- **Revascularization not considered**
- **Inadequate patient education**
- **Inappropriate monitoring of progress**
    - **Testing overutilized**
    - **Activity- and symptom-based measures underutilized**

Indications for Hospital Management

- **Clinical or ECG evidence of acute myocardial ischemia**
- **Pulmonary edema or severe respiratory distress (O_2 sat <90%)**
- **Severe complicating medical illness**
- **Anasarca**
- **Symptomatic hypotension or syncope**
- **Failure of outpatient management**
- **Inadequate home support**

Diastolic Heart Failure

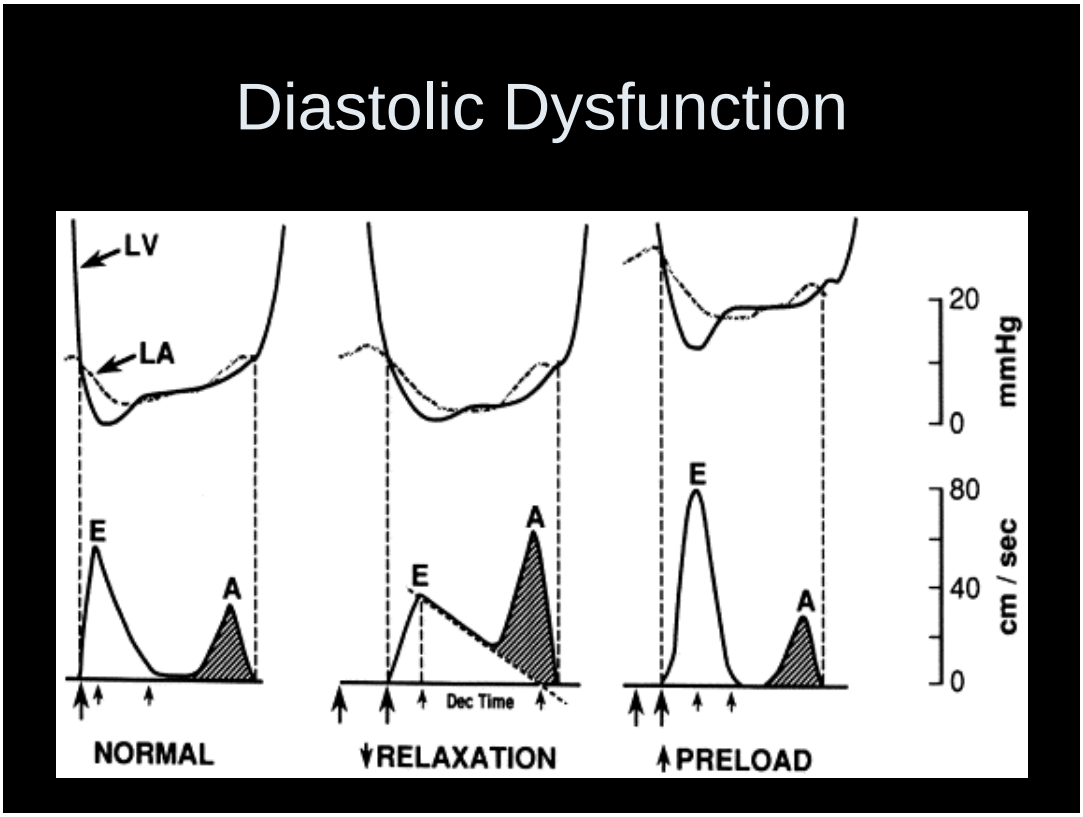
Symptoms and signs of CHF Normal LV function Diastolic dysfunction

- **Syndrome of dyspnea, fatigue and fluid retention in presence of normal LV function (in absence of heart valve disease)**
- **Disastolic dysfunction; abnormal ventricular distensibility, relaxation or filling regardless of presence or absence of symptoms and normal or abnormal LV function**
- **Prevalence: 15% of CHF patients <65 yrs.**
  50% of patients with CHF >80 yrs.

Causes of Left Ventricular Diastolic Dysfunction

- **Left ventricular hypertrophy:**
    - **Hypertensive heart disease**
    - **Aortic stenosis**
- **Ischemic heart disease**

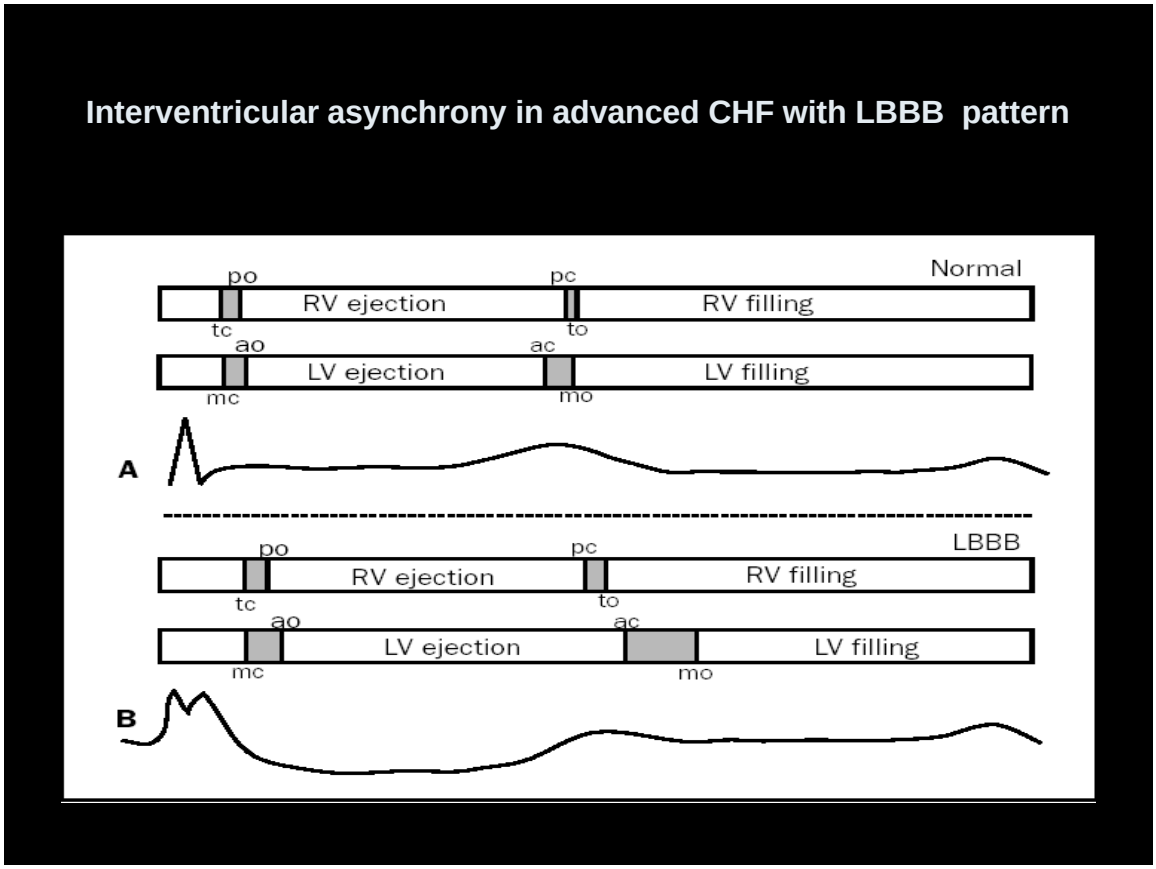
- **Cardiomyopathy**
    - **Hypertrophic cardiomyopathy**
    - **Infiltrative cardiomyopahty – amyloidosis, sarcoidosis, hemochromatosis**
- **Pericardial disease: constrictive pericarditis effusion with tamponade**
- **Diabetes mellitus**



Diastolic Heart Failure: Treatment Goals and Methods

• **Reduce the congestive state** **Salt restriction and diuretics** **ACE inhibitors or angiotensin receptor blockers** **Dialysis or plasmaphoresis** • **Control hypertension and promote regression of LVH** **Antihypertensive agents** • **Prevent and treat myocardial ischemia** **Nitrates, beta blockers, calcium blockers** **Bypass surgery, angioplasty**	• **Prevent tachycardia** **Beta-blockers, calcium blockers** **Ablation of AV node and pacing** • **Maintain atrial contraction (Sinus rhythm)** **Antiarrhythmic agents** • **Improve LV relaxation** **Beta adrenergic stimulation** **Systolic unloading** **Treat ischemia** **Calcium-blockers (in hypertrophic cardiomyopathy)**

• **Prevent fibrosis and promote regression of fibrosis** **ACE inhibitors or angiotensin receptor blockers** **Spironolactone** **Anti-ischemic agents**	• **Attenuate neurohormonal activation** **Beta-blockers, ACE inhibitors**



Consequences of LBBB

Mechanical:

- **Interventricular dyssynchrony**
- **Prolonged delay between onset of LV and RV contraction**
- **Relative decrease in the duration of LV diastole**
- **Prolonged IVRT, Shortened LV filling period**
- **Intraventricular dyssynchrony**
- **Paradoxical septal motion with decreased regional ejection fraction**
- **Inhomogenous, discoordinate LV contraction.**

Hemodynamic:

- **Reduced LVEF / CO / MAP / dP/dt**

Surgical treatment for heart failure

- **Heart transplant (including xenotransplantation)**
- **Cororнary artery bypass surgery**
- **Left ventricular restoration**
- **Mitral valve repair / replacement**
- **Left ventricular assist devices**
- **Abiocor artificial hearts**

Other non-surgical measures:

- **Biventricular pacing**
- **Intermittent inotropic infusions**